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International Scientific Collaboration through the Scientific Committee on Antarctic Research (SCAR)

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Abstract/executive summary (ca. 200 words):

International scientific collaboration in Antarctic Research is supported by the Scientific Committee on Antarctic Research (SCAR). Throughout the history of SCAR, collaboration has expanded and now includes a number of nations; covering a large range of disciplines and issues. Although barriers to participation in SCAR initiatives exist, SCAR has a number of capacity building initiatives which aim to increase collaboration and participation in Antarctic research. This paper will look at the history of collaboration through SCAR, the barriers to participation and will show that efforts towards expanding international collaboration are plentiful and effective.

Introduction

International scientific collaboration in Antarctica is important in order to address questions or issues that need more information, time or resources than any one person or one country can invest. This is especially pertinent in the 21st Century, where large scale climate change is at our heels and where the importance of Antarctica as a part of the global earth system is being realized.

The Scientific Committee on Antarctic Research, or SCAR as it is generally referred to, is widely agreed to be the most influential non-governmental organization that has a part to play in international Antarctic governance (Walton, 2009). SCAR aims to aid in international scientific collaboration, while supporting the science that occurs in the Antarctic region through a variety of initiatives. These initiatives will be discussed in detail throughout this report.

Born out of the International Geophysical Year of 1957/58, SCAR was set up as a Special Committee by the International Council of Scientific Unions (ICSU) to co-ordinate scientific efforts during this period (Walton and Clarkson, 2011). Because of its success, however, it was decided that SCAR would become a permanent apparatus of the ICSU and has continued to co-ordinate scientific activities in the Antarctic region for the past five decades (Summerhayes, 2008). SCAR aims to co-ordinate pan-Antarctic science which is beyond the capabilities of any one of its individual members. SCAR's membership now consists of 39 national academies of science and 9 international scientific unions, which has grown from the 4 member countries and 4 ICSU unions who joined in 1958 (a list of current members can be found in Table 1) (scar.org, 2016). To some extent, this alone shows SCAR's success in rallying nations to participate in collaborative efforts. By annually reporting to the Antarctic Treaty Consultative Meetings (ATCMs) on a variety of scientific and environmental matters and presenting Information and Working Papers, SCAR also plays an important role Antarctic governance (Walton, 2009).

SCAR has an integral role to play in supporting international scientific endeavours in Antarctica and the Southern Ocean. SCAR has conceived a variety of initiatives which aid in international scientific collaboration in the Antarctic region, including international collaborative scientific projects, scientific capacity building and outreach programs (scar.org, 2016). However, there are some countries which are particularly active in SCAR initiatives, while others are less so. This report will discuss the barriers to participation in Antarctic science, while also discussing the programs SCAR runs in order to combat this lack of participation.

The future may hold challenges for Antarctic science, with an increase in amount of States who are likely to have an input, as well as continuing environmental pressures, both locally and globally, making Antarctic science forever more relevant and arguably, more valuable. Because of this, it is likely that international collaboration into the future will play an even more important role.

Table 1: List of SCAR Members (source: scar.org)

Current SCAR Members (as at February, 2016)	
National Committees:	
Argentina	Monaco (Associate Member)
Australia	Netherlands
Belgium	New Zealand

Brazil Bulgaria Canada Chile People's Republic of China Czech Republic (Associate Member) Denmark (Associate Member) Ecuador Finland France Germany Iran (Associate Member) Italy Japan The Republic of Korea Malaysia	Norway Pakistan (Associate Member) Peru Poland Portugal (Associate Member) Romania (Associate Member) Russia South Africa Spain Sweden Switzerland Ukraine The United Kingdom The United States of America Uruguay Venezuela (Associate Member)
Union Members: International Astronomical Union (IAU) International Geographical Union (IGU) International Union for Quaternary Research (INQUA) International Union of Biological Sciences (IBUS) International Union of Geodesy and Geophysics (IUGG)	International Union of Geological Sciences (IUGS) International Union of Pure and Applied Chemistry (IUPAC) International Union of Physiological Sciences (IUPS) International Radio Scientifique International (URSI)

The History of Scientific Collaboration in Antarctica and the Birth of SCAR

Arguably, international scientific collaboration in the Antarctic region extends back to the first International Polar Year (IPY) of 1882-1883, which was sponsored by the International Meteorological Organisation (IMO) (Summerhayes, 2008). However, at this time relatively little was known about Antarctica and its surrounding oceans and therefore a large amount of the science was instead focussed on the Arctic region (Summerhayes, 2016). Antarctica at this time was seen as a difficult place to access and a place where more resources were required in order to conduct scientific activities in the region (Summerhayes, 2016). However, after the explorations of Sir James Clarke Ross in 1839-1843, the idea of Antarctic science started gaining some traction and with the help of some eminent champions, Antarctica was included to some extent in the first IPY (Summerhayes, 2008). In particular, both France and Germany set up stations in the Southern Hemisphere for the first IPY. Germany had stations both at Stanley in the Falkland Islands and on South Georgia (Summerhayes, 2008). These stations were focussed on collecting meteorological, magnetism and oceanographical data. Although the first IPY was one of the largest scientific endeavours that a large number or countries had collaborated on together, Antarctica wasn't the main focus and the data which came from the year was handled in a way which meant that it was less valuable than it had the potential to be (Walton, 2009).

In 1895, the International Geographical Congress made Antarctica the focus for new exploration, after which the Heroic Age of Discovery within Antarctica began. During this period, a number of national scientific expeditions headed south, with the first crews overwintering in Antarctica in 1897-1899 on the *Belgica* (Summerhayes, 2008). The *Belgica* expedition was the first truly international scientific endeavour in Antarctica, with crew members from Norway, the United States, Belgium, Romania and Poland. Interest in Antarctic science radically increased throughout the early 20th Century, with many national expeditions for both scientific and exploration purposes (Walton and Clarkson, 2011).

In 1932-33, a second IPY was held to commemorate the 50 year anniversary of the first IPY. The second IPY had a larger presence in Antarctica than the first IPY, however the focus of the research was similar, with magnetism, meteorology, oceanography and atmospheric sciences being the main areas of research (Summerhayes, 2016). In particular, a focus was put on discovering how weather observations at the poles could improve the accuracy of weather forecasts worldwide. However, because the second IPY took place in a period of global economic depression, less was achieved than first envisioned and only 2 research stations were placed south of 50 Degrees during this time (Summerhayes, 2008).

The International Geophysical Year of 1957/58 revolutionized Antarctic science and international collaboration in the Antarctic region. The IGY saw the establishment of many national scientific research stations in Antarctica by the 12 participating nations, those being Argentina, Australia, Belgium, Chile, France, Great Britain, Japan, New Zealand, Norway, South Africa, USSR and the USA (Belanger, 2004). The IGY was one of the largest organized international scientific endeavours of the 20th Century and led to significant advances in meteorology, atmospheric sciences and geophysics (Walton, 2009). Overall, the IGY was an integral part of the formation of current international scientific collaboration and national Antarctic programs. Also, quite fundamentally, the IGY was instrumental in the creation of the Antarctic Treaty in 1959 (Summerhayes, 2008).

Although the IGY was undoubtedly a significant international scientific effort, the actual science conducted during this period was mainly separated into individual countries who were working under the same banner of the IGY (Summerhayes, 2016). International scientific collaboration became more prominent after the International Geophysical Year and therefore by looking at the history of SCAR, we can also trace the history of international collaboration in the Antarctic region.

SCAR predates the Antarctic Treaty, which was signed in December 1959. Although SCAR has always had a close link with the Antarctic Treaty System (ATS) since the first Antarctic Treaty Consultative Meeting (ATCM) in 1961, SCAR was only officially granted observer status in 1987 and therefore able to attend ATCMs and submit Working and Information Papers (Walton, 2009). Before this time, SCAR mainly interacted with the ATS through giving scientific advice to national delegations, who would then attend the ATCMs (Walton, 2009). The first official SCAR meeting was held at The Hague in 1958. The 12 participating nations of the IGY were invited to attend, as well as representatives from five scientific unions. From this, an Executive committee was elected and a constitution drafted (Summerhayes, 2008). In particular, SCAR's aim at this time was to ensure that the science and the collaboration which occurred in the IGY should continue into the future.

Over the past five decades since its creation, SCAR has played a significant role in the co-ordination of scientific activities in Antarctica, as well as being instrumental in many Antarctic Treaty Conventions. SCAR was particularly instrumental in the development of the Convention for the

Conservation of Antarctic Seals by providing scientific advice through the Biology Working Group (Walton, 2009). Throughout the 1970's SCAR worked to research marine resources and their ecosystems and established a Group of Specialists on Southern Ocean Ecosystems and their Living Resources in 1975 (Walton, 2009). This group then turned into the Biological Investigations of Marine Antarctic Systems and Stocks (BIOMASS) group, with endorsement from the United Nations Food and Agriculture Organization and other high profile research organisations (Walton and Clarkson, 2011). The BIOMASS project became a large scale international scientific investigation, involving 11 countries and spanning over a decade. As well as significantly developing the scientific knowledge around Antarctic marine ecosystems, the BIOMASS project inspired the ATCPs to pass a new governance method for the Southern Ocean; the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) (Walton, 2009). CCAMLR came into force in early 1982 and aimed to manage fisheries in the Southern Ocean using sustainable fish stock analysis, based on scientific advice that was provided by SCAR.

Overall, SCAR has had an important role to play in the co-ordination of scientific activities in the Antarctic region since its establishment in 1958. By looking at its history we can see that it has been instrumental in guiding Antarctic governance with accurate scientific information, rather than political interest, something which it continues to do in current times.

The Organization of SCAR and Current Programs

In the early days of SCAR, logistical operations within Antarctica were included within the scope of what SCAR dealt with, namely through the SCAR Working Group on Logistics (Walton, 2009). However, this group never particularly gelled well with the scientific side of SCAR business and therefore the Council of Managers of National Antarctic Programs (COMNAP) was formed in 1988 (Walton, 2009). After this, logistical matters and their managers became entirely separate to SCAR, who narrowed their scope of operation.

In 2000, SCAR underwent a reorganization. The motivation to do this arguably came from a variety of reasons, including the formation and breakaway of COMNAP, a change in the Executive Secretary, as well as changes in science trends which saw Antarctic science become of global significance (Walton and Clarkson, 2011). In order to reorganize SCAR, an ad hoc group was established to propose a review to SCAR. In 2002, at the XXVII SCAR Meeting, the implementation of this review was agreed upon. The review meant that an executive director was appointed, many new programmes were formed and funding was increased (Walton, 2009). The reorganization also led to the establishment of the biannual SCAR Open Science conferences, as well as capacity building, which are both important tools to assist with international collaboration (scar.org, 2016).

SCAR currently has a number of programmes which facilitate and encourage scientific research in the Antarctic region. Most of SCAR's work is carried out through its Standing Scientific Groups (SSGs), Scientific Research Programmes (SRPs), Expert Groups, Action Groups, Advisory Groups, as well as groups which are co-sponsored with other research organisations (SCAR Organization, scar.org, 2016). The function of SSGs is to identify areas where research is lacking, to co-ordinate proposals for future research to be conducted by national Antarctic programs and to share information on the research being conducted (scar.org, 2016). The SSGs are also responsible for setting up Action and Expert Groups which aim to address specific questions within a discipline. The SSGs are broken up into three broad disciplines, those being GeoSciences, Life Sciences and Physical Sciences. As well as SSGs, SCAR also has a number of Standing Committees which focus on data sharing, education, communication and outreach (scar.org, 2016). The full organization of SCAR can be found in Figure 1.

SCAR's science focus is on a variety of topics, including climate change, ecosystem structure & functioning, astronomy, paleo-climate records, sub-glacial environments and oceanography. As well as scientific research, SCAR also has a Humanities and Social Science Expert Group (HASSEG), which is focussed on identifying the values associated with Antarctica.

By focussing research into particular areas, SCAR can effectively identify what research needs to be carried out and devise a plan in order to ensure that the research is conducted and that goals are met. Because of its non-governmental status, SCAR also has the ability to focus on research, rather than adhering to political agendas (Walton, 2009). In the 2011-2016 Strategic Plan, SCAR outlines the research areas where its focus lies, as well as stressing the importance of partnerships with other organizations, data management and communication. In particular, it states that SCAR's main focus is to understand the Antarctic region's role in the Earth System (SCAR Strategic plan, scar.org, 2011). As well as this, it places an importance on Emerging Frontiers which is an interdisciplinary approach to global issues.

International collaboration through SCAR is achieved by specific research being facilitated in the Antarctic region, depending on what has been identified to be important, as well as participation in SCAR initiatives, participation in Open Science conferences and by input at the biennial SCAR Meetings.

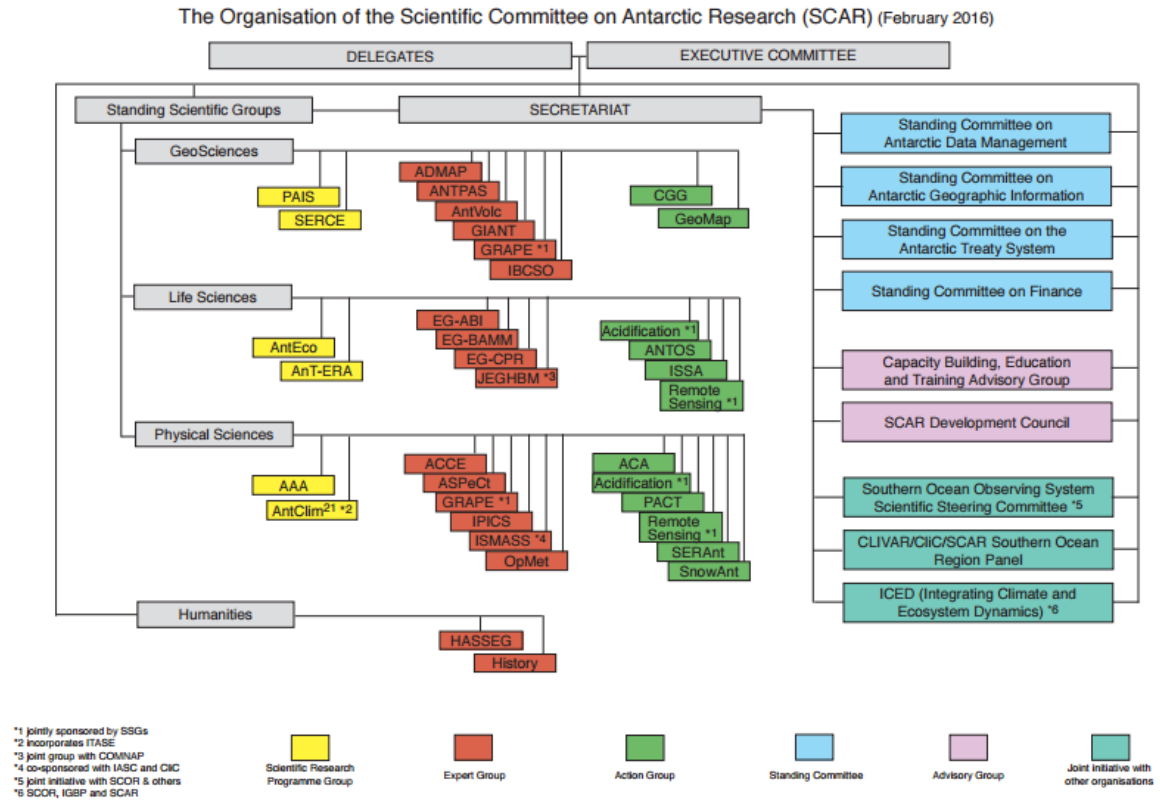

Figure 1: Organization of SCAR (source: scar.org, retrieved: 20th of February, 2016)

The Main Participants of SCAR Programs

Of the 39 national members of SCAR, it is evident that some countries are more active than others in SCAR projects and initiatives. This may be due to a variety of reasons, including a nation's science

capacity, language issues and overall Antarctic involvement. In terms of international collaboration, we need to consider both participation in SCAR initiatives and the administrative side of SCAR, as well as the actual scientific projects.

If we look at the running of SCAR as an organisation, there are notably countries who are much more prominent in becoming involved in the organization of SCAR workshops, symposia and with the running of Standing Groups and Standing Committees. For example, if we look at SCAR's most recent contribution to the Antarctic Treaty Consultative Meetings and the Committee for Environmental Protection at XXXVIII ATCM and CEP XVIII in Bulgaria in 2015, there are a small number of SCAR countries who have presented the bulk of the Working Papers and Information Papers for SCAR (Bulletin 193, scar.org, 2015). These countries include New Zealand, Australia, the U.S, Belgium and Norway. Looking back through the past ten reports of SCAR to the ATCM, from 2006 until 2015, there is an emerging trend of countries being listed, with those above being prominent, as well as the United Kingdom and Chile to some extent, with Belgium having a more variant level of participation over the years (SCAR Reports, scar.org, 2006-2015).

If we look at SCAR initiatives individually, we can also see that there is a trend of countries who are more involved than others. For example, the Southern Ocean Observing System (SOOS) is a new international SCAR initiative established at the end of 2011, which aims to *establish a multidisciplinary observing system to deliver the sustained observations of the Southern Ocean* (soos.aq, 2016). SOOS is based in Hobart, Australia and run by a team of Australians, while being supported by Antarctica New Zealand. As well as this, the Antarctica Environments Portal, which is also a fairly new initiative established in 2014, is run by Antarctica New Zealand, with support from the Australian Antarctic Division, Monash University (Australia), the Norwegian Polar Institute and the Université Libre de Bruxelles, Belgium (Antarctic Environments Portal, 2016). The Antarctica Environments Portal makes science-based information widely available, in particular to inform Antarctic Treaty Consultative Parties of the latest scientific information in order to guide governance decisions.

There are a number of international scientific projects that have been conducted in recent years and are continuing to run. SCAR often has a role in facilitating, supporting or else gaining data from these projects. Many of the projects are focussed around investigating Antarctica's place in the global earth system, which is also a focus of SCAR. A large amount of these projects were conducted during the fourth International Polar Year which was held in 2007-2008 or are legacies from this period (IPY, 2016). The fourth IPY deviated from the past IPYs in that it involved a large range of scientists from a variety of countries working across disciplines towards common goals. This was fairly revolutionary for Antarctic science and hence, a large amount of significant work came from the year (IPY, 2016). An example of an IPY project which involves a large component of scientific collaboration is the Antarctica's Gamburtsev Province (AGAP) which involved the United States, China, Australia, Germany, Russia and the United Kingdom (BAS, 2015). The project located river valleys in the Gamburtsez Mountains under the Antarctic ice sheet (Erb, 2009). This was a significant find as it hinted at the existence of very old water underneath the ice. This project involved a large amount of collaboration between a number of countries, both scientifically and logistically (BAS, 2015).

Another IPY project which involved a large amount of collaboration was the Larsen Ice Shelf System (LARISSA), which involved collaboration between Argentina, Belgium, South Korea, the United States and Ukraine (Erb, 2009). The project involved studying the Larsen Ice Shelf System which has suffered from significant rapid environmental change over the past two decades. The Larsen Ice

Shelf system is unique as it is a local phenomenon which potentially has global implications (Erb, 2009).

Furthermore, another project which has required a large amount of scientific collaboration is the Antarctic Geological Drilling Program (ANDRILL), which is contributed to by Italy, Germany, the United Kingdom, the United States and New Zealand. The ANDRILL project has led to the extraction of sediment cores which has given insights into the climate of Antarctica up to 30 million years ago (Erb, 2009). The ANDRILL project has been a significant contributor to knowledge of Antarctica's role in the global climate system and arguably could not have been achieved without the collaboration which has occurred (Erb, 2009).

International scientific collaboration in Antarctica has made significant leaps since the IGY of 1957/58. However, there are still barriers which exist which hinder the full potential of Antarctic science being reached.

Barriers to Participation

Although there are large collaborative research efforts being conducted in the Antarctic region, there is still a disparity between those countries who have a large involvement in SCAR initiatives and Antarctic science more broadly and those who do not. A bibliometric analysis conducted on Antarctic science journal papers published between 1993 and 2012 showed that overwhelmingly, the US published the most Antarctic related journal articles, with the UK, Germany, Australia, France and Italy following behind them (Ji et al, 2014). Perhaps unsurprisingly, these are also the countries who have a large part to play in SCAR initiatives and have substantive Antarctic programs (scar.org, 2016). However, there are also countries who have less involvement in SCAR initiatives and Antarctic science, albeit being members of SCAR. This may occur due to a variety of reasons, including language barriers, having small and new Antarctic programmes and a lack of scientific capacity, particular in developing nations (SCAR Strategy for Capacity Building, scar.org, 2006).

One barrier to participation is that a number of SCAR members only have small, newly established Antarctic programs, which make it harder for them to produce the amount of data or papers that a well-established Antarctic nation may have, as well as potentially restricting the amount of SCAR initiatives they may be able to be involved with (SCAR Strategy for Capacity Building, scar.org, 2006). As well as this, having a smaller Antarctic program creates more logistical restrains for science to occur, so priorities may need to be made. As well as this, there are a number of SCAR members that are classified as being developing nations which may limit their capacity to conduct scientific research in Antarctica and to participate in SCAR initiatives (SCAR Strategy for Capacity Building, scar.org, 2006). Language may also be a barrier for participation. The Antarctic Treaty Consultative Meetings have four official languages, these being Spanish, Russian, English and French, which is stipulated in their Rules of Procedure (ATS, 2015). Other members are allowed to speak in other languages, but must have it translated into one of the four official languages. Understandably, this may create a language issue at a governance level, but one which may also infiltrate SCAR initiatives and Antarctic science generally. It has been argued that generally scientific papers which aren't published in English are less cited and are less read than those published in English (Meneghini and Packer, 2007). This may have an effect on some SCAR Members becoming heavily involved in SCAR projects and Antarctic research.

Overall, there some large barriers for some members to participate in SCAR initiatives and this is

most likely why we see a trend of nations who participate a great deal, while others have a low level of participation. However, SCAR is working on a number of initiatives to incite collaboration and to overcome these barriers.

SCAR Initiatives to Overcome Barriers

SCAR has a number of initiatives to aid in collaboration and to ensure that all of its members have the capacity to participate in SCAR initiatives and to be able to conduct research in the Antarctic Region. The initiatives include scientific capacity building, outreach, education, data sharing techniques and SCAR fellowships. These methods for increased collaboration are detailed below.

In SCAR's 2011-16 Strategic Plan, it was stated that *"SCAR is committed to developing scientific capacity in its Members, emerging National Antarctic programmes, students and early career scientists. SCAR also aims to recruit countries that have not traditionally participated in Antarctic research"* (SCAR Strategic plan, scar.org, 2011). In the previous SCAR Strategic Plan (2004-2010), SCAR had an objective to raise the scientific capacities of all of its members, particularly in developing countries. In the most recent Strategic plan, SCAR also aimed to promote the incorporation of Antarctic science in all levels of education (SCAR Strategic plan, scar.org, 2011). As a part of this, the Capacity Building, Education and Training (CBET) Advisory Group was formed and a Strategy for Capacity Building and Education created. This Strategy was also in line with the ICSU's capacity building strategy, which aimed to increase the capacity of all of its members and to include early career polar professionals in their strategy (ICSU, 2006). The capacity building strategy aims for members to engage in research in the Antarctic region, participate and contribute to SCAR's programs, provide data on their research and to be able to provide data to their respective governments, as well as to Antarctic Treaty Consultative Meetings. The Capacity Building Strategy complements SCAR's communication plan which calls for Antarctic Science to be integrated into education in order for awareness to increase (SCAR Strategy for Capacity Building, scar.org, 2006).

SCAR has a variety of methods which it is employing in order to achieve its capacity building goals. These include SCAR fellowships, between 3 and 5 of which are offered each year. These fellowships allow students to study abroad in international polar institutes in order to gain experience and to increase international collaboration (SCAR Strategy for Capacity Building, scar.org, 2006). SCAR also supports researchers to travel to countries who have well-developed Antarctic programmes and to participate in joint programmes or joint study programs. Furthermore, SCAR also runs a variety of symposia, workshops and lecture series which are aimed at increasing the audience for the findings of Antarctic research and to widely educate researchers and others on Antarctic matters (SCAR Strategy for Capacity Building, scar.org, 2006). SCAR also aims to help researchers from countries whose Antarctic program is less well-developed to publish in large well-known scientific journals, by offering advice on language (SCAR Strategy for Capacity Building, scar.org, 2006).

SCAR also helps to facilitate international scientific collaboration by supporting a number of data sharing and management platforms. SCAR does so by promoting easily accessible methods of archiving and data sharing. SCAR's Standing Committee on Antarctic Data Management (SCADM) have developed and adopted a Data and Information Management Strategy (DIMS) (SCADM, scar.org, 2016). DIMS aims to ensure that "the scientific user community has adequate access to data and information" (SCADM, scar.org, 2016). This is being worked on through data portals such as SOOS and the Antarctic Environments Portal, as well as SCAR supporting the establishment of national Antarctic data centres, which is still a work in progress for most SCAR Members (Cooper,

2013).

After the reorganization of SCAR in 2000, a number of workshops, symposia and the conferences were introduced in order to rejuvenate SCAR and to assist in collaboration (Walton, 2009). SCAR's largest public event is the biennial Open Science Conference which runs alongside the SCAR Meetings. The Open Science Conference allows researchers from many different nations to convene, share knowledge and discuss Antarctic research (2016 OSC, scar.org, 2016). This conference is an effective tool in both increasing international collaboration, but also increasing the overall awareness of Antarctic research.

Conclusion

Scientific collaboration in Antarctica has had a long history, arguably starting in the First IPY. In particular, collaborative research efforts increased a large amount after the Geophysical Year of 1957/58 and the establishment of SCAR in 1958. SCAR aims to maximise the amount of Antarctic Research that is undertaken, in order to gain a further understanding of the role of Antarctica in the global earth system.

Overall, scientific collaboration is integral in order to look at large issues which may stretch across many disciplines and areas and that are beyond the capabilities of any one Member. Although there are some barriers to participation in SCAR programs, as well as to Antarctic Science more generally, there are a large amount of positive initiatives which aim for increased collaboration. Hopefully in the future, SCAR will continue to facilitate research in the Antarctic Region and increase participation for all Members in order to increase awareness and understanding of Antarctica's unique environment.

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